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5. Upgrading Septic Tanks Using Microbial/Plant Filters

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Abstract. The application of septic tanks can be enhanced by replacing septic tank leaching fields with microbial/plant filters. BOD_5 and total suspended solids (TSS) can be reduced below the EPA secondary effluent discharge standing of 30 mg/ℓ or less by adding plastic-lined reed (*Phragmites communis*)/microbial rock filters in series with septic tanks. Nutrient removal can also be accomplished by adjusting the filter depths and the hydraulic detention time.

Introduction. The disposal of domestic wastewater in such a manner as to prevent contamination of surface and groundwater is a never-ending struggle. Partially treated waste from septic tanks can slowly seep into groundwater supplies from which rural and urban populations receive their drinking water.

Septic tanks are used principally for treatment of waste from individual residences. In rural areas they are also used for establishments such as schools, parks, rest areas, and private developments. The septic tank is a simplified form of an anaerobic digester. Waste is partially degraded and stabilized by anaerobic microorganisms which live in the absence of free oxygen and utilize chemically bound oxygen to metabolize and break down organic materials found in wastewater. Effluent from anaerobic digesters such as septic tanks normally consists of a dark, odorous sulfide liquid solution still high in biochemical oxygen demanding (BOD) substances which require further treatment. This liquid fraction from a septic system is distributed back into the environment via a drain field under standard operating conditions.

In areas where septic tank systems are very concentrated such as private developments, the land can become saturated with the septic discharge. Excess organics, nutrients, etc. can cause unacceptable odors and saturate the earth in the vicinity of the drain field with the runoff polluting nearby lakes and streams.

Recently an advanced wastewater treatment process has been developed at NSTL through a joint NASA/EPA program which combines microbial filter technology with the vascular aquatic plant wastewater treatment technology to produce an efficient hybrid system (1-4). This system uses rooted, cold-tolerant plants such as the common reed (*Phragmites communis*) growing in the surface area of a microbial rock filter bed.

The reed/microbial filter unit can be used to further treat wastewater from which the sludge has been removed such as that from a septic tank. A plastic-lined plant/microbial rock filter can be used to replace drain fields normally used with septic tanks. This new system will allow septic tanks to be installed in most any location. Combination septic tank and plant/microbial rock filter systems were used to replace aerated package plants at the North and South Reception Centers at the National Space Technology Laboratories. Data from the first year of operation of these new systems is presented in this report and compared to the previous year's average data from the aerated package plants.

Description of Systems. In 1981 an aerated package treatment system at NSTL's South Reception Center was replaced with a septic tank and reed (*Phragmites communis*)/rock filter system (Figure 1). The system consists of a 3.8 m^3 (1,000 gal) septic tank in series with a reed/rock filter. The filter bed consists of a metal trough measuring 1.22 m x 1.83 m x 2.74 m (4' x 6' x 9'). The trough was filled almost to the top with rocks (2.5-7.6 cm in diameter). The top 15 cm was filled with pea gravel (0.25-1.27 cm in diameter) and planted with reeds (*Phragmites communis*). The resulting filter bed has an estimated void volume of 3.0 m^3 (800 gal). The system receives approximately 1.9 m^3 (500 gal) of raw sewage per day from 15-18 office workers.

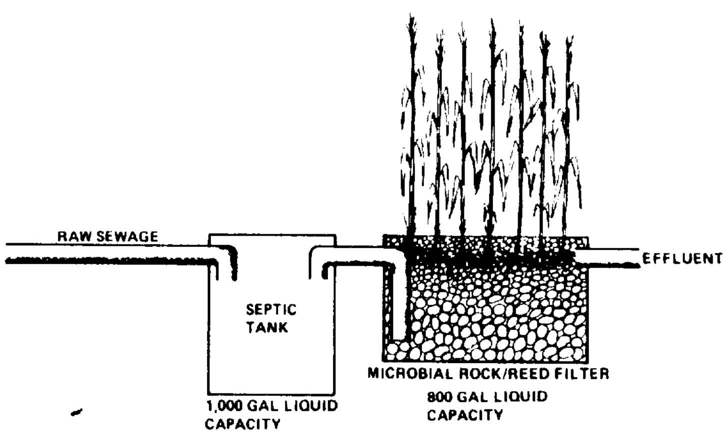

Figure 1. NSTL South Gate Wastewater Treatment System

In 1982 the aerated package plant at the NSTL North Reception Center was also replaced with a 3.8 m^3 (1,000 gal) septic tank and a similar rock filter bed having an estimated void volume of 1.9 m^3 (500 gal). The filter was covered with plastic and maintained free of reeds. The effluent from the anaerobic filter flows through a third component consisting of 6.1 m (20 ft) of 25.4 cm (10") diameter plastic pipe containing reeds planted in rocks (2.5-7.6 cm in diameter). Holes were cut out of the top of the pipes for adding rocks and plants (Figure 2). This system receives approximately 1.9 m^3 (500 gal) daily of wastewater from 15 office workers.

Monitoring and Analytical Procedures. Grab samples were collected from discharge points once a week. Due to the configuration of the system, it was not possible to collect an initial sample or one from the septic tank discharge point. The samples were analyzed for 5-day biochemical oxygen demand (BOD_5), total suspended solids (TSS), dissolved oxygen (DO), and pH according to *Standard Methods* (5).

Results. By adding reed/microbial filters to anaerobic digesters or septic tanks, a high quality effluent can be obtained. Figures 1 and 2 show how package plants can be replaced by septic tanks and filters or how septic tanks can be upgraded to produce a high quality waste effluent.

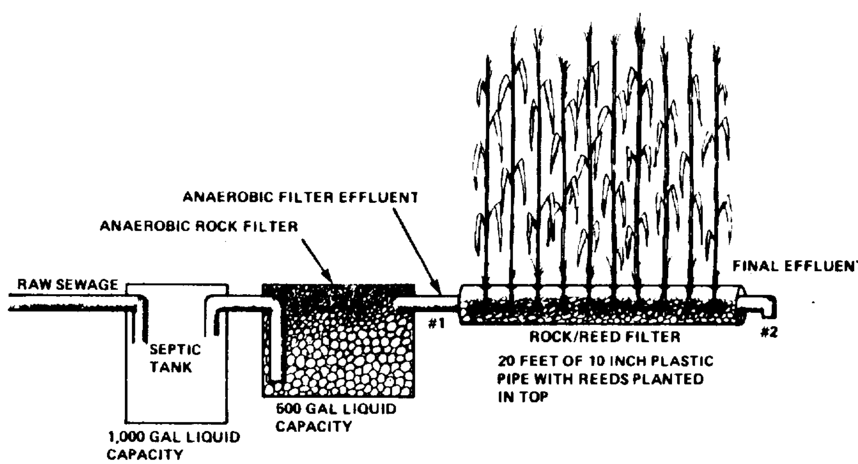

Figure 2. NSTL North Gate Wastewater Treatment System

NSTL domestic wastewater effluents must meet EPA and State secondary standards of 30 mg/ℓ or less of BOD_5 and total suspended solids (TSS). So the objectives in replacing the package plants at the reception centers with septic tank/reed-rock filters were to meet EPA and State standards while reducing maintenance and operating costs to NSTL. Tables 1 and 2 demonstrate the efficiency of this hybrid system in meeting secondary standards while eliminating practically all operational and maintenance costs. Table 3 demonstrates the poor quality of effluent discharged from the package plants during 1979. All data on the new hybrid system obtained to date from both the South and North Reception Centers are similar to the first-year data presented in Tables 1 and 2.

Discussion. The design of a plant/microbial rock filter for BOD_5 and TSS reduction is less critical as to depth and hydraulic detention time if nitrification/denitrification is not important. The NSTL effluent discharge permits do not require nutrient removal. Therefore, conditions for nutrient removal were not considered in constructing these systems.

Reduced forms of nitrogen such as ammonia and organic nitrogen are normally found in effluent from anaerobic treatment processes such as septic tanks. Therefore, the design for nitrogen removal from septic tank effluent is critical as to depth of filter and hydraulic detention times. Since autotrophic nitrifying bacteria have a growth rate that is much slower than the heterotrophic bacteria which predominates in the anaerobic septic tank, a longer mean cell residence time is required in the plant/rock filter system. Aquatic plants such as reed (*Phragmites communis*) release small amounts of oxygen from their roots into water in which they grow. Recent studies with plant/rock filters (4) suggest that aquatic plant roots are contributing sufficient oxygen to septic tank-type effluent liquid to enhance nitrification, but not enough to sustain this zone in a complete aerobic state. Therefore, anoxic conditions conducive to denitrification also prevail. Since nitrite is an intermediate in both the nitrification and denitrification processes, the most probable N pathway is:

$$\text{Organic Nitrogen} \xrightarrow{\text{Ammonification}} NH_4^+$$

$$\xrightarrow{\text{Partial Nitrification}} NO_2 \xrightarrow{\text{Dentrification}} N_2 \uparrow$$

So one must consider the effluent quality desired in designing the plant/rock filter for treating effluent from anaerobic processes. Shallow filter depths with increased hydraulic detention times are required to achieve nitrification/denitrification.

By replacing leaching fields with plastic-lined rock/plant filters, septic tanks can be used in areas where they were previously banned. Lakefront developments that presently have septic tanks are excellent candidates for upgrading using this filter process.

Table 1. Data from Wastewater Treatment System Shown in Figure 1.

NSTL SOUTH GATE WASTEWATER EFFLUENT QUALITY

REED/MICROBIAL FILTER SYSTEM
AV. MONTHLY CONC., MG/L

MONTH	BOD_5	TSS	DO	pH
AUGUST 1981	11	6	5.0	7.4
SEPTEMBER	13	2	5.3	7.4
OCTOBER	15	4	5.7	7.5
NOVEMBER	21	4	6.0	7.5
DECEMBER	20	7	5.1	7.4
JANUARY 1982	18	1	5.0	7.6
FEBRUARY	21	12	5.0	7.4
MARCH	18	17	5.5	7.7
APRIL	23	5	5.0	7.6
MAY	12	5	5.0	7.8
JUNE	16	15	3.1	7.8
JULY	18	8	3.0	7.7

Table 2.

NSTL NORTH GATE WASTE WATER EFFLUENT QUALITY

REED/MICROBIAL FILTER SYSTEM
AV. MONTHLY CONC., MG/L

MONTH	BOD_5		TSS		DO		pH	
	#1	#2	#1	#2	#1	#2	#1	#2
AUGUST 1982	34	7.4	10.5	0.5	0.7	2.0	7.5	7.7
SEPTEMBER	27	9.0	9.0	0.6	0.8	2.8	7.5	7.4
OCTOBER	27	6.5	9.3	2.0	0.8	2.3	7.5	7.6
NOVEMBER	42	9.0	8.8	2.0	1.0	2.2	7.6	7.7
DECEMBER	46	9.4	21.6	4.0	1.2	3.1	7.6	7.6
JANUARY 1983	51	15.7	16.0	10.0	0.9	3.5	7.4	7.6
FEBRUARY	42	11.7	32.0	24.0	1.0	4.7	7.3	7.5
MARCH	56	24.0	42.7	8.0	1.5	3.5	7.1	7.3
APRIL	47	16.0	16.0	0.7	0.8	3.2	6.9	7.2
MAY	50	25.0	36.8	0	1.1	2.6	6.9	7.1
JUNE	36	16.2	36.8	7.2	0.8	2.4	7.0	7.3
JULY	34	7.3	39.0	4.0	0.9	2.6	7.1	7.4

#1 = ANAEROBIC ROCK FILTER EFFLUENT

#2 = MICROBIAL/REED ROCK FILTER EFFLUENT

E.P.A. Permit Levels of 30 mg/l or Less of BOD_5 and TSS Required

Table 3.

NORTH AND SOUTH GATE WASTEWATER EFFLUENT QUALITY FROM AERATED-PACKAGED PLANTS BEFORE REPLACEMENT

Yearly Average for 1979, mg/ℓ

	BOD_5	TSS	DO	pH
North Gate	113	123	5.9	7.7
South Gate	91	106	5.4	7.4

LITERATURE CITED

Wolverton, B. C. and Rebecca C. McDonald. 1981. Natural processes for treatment of organic chemical waste. *The Environmental Professional,* 3:99-104.

Wolverton, B. C. 1982. Hybrid wastewater treatment system using anaerobic microorganisms and reed (*Pragmites communis*). *Economic Botany,* 36(4):373-380.

Wolverton, B. C. and Rebecca C. McDonald. 1982. The role of vascular aquatic plants in wastewater treatment. *The Herbarist,* 48:24-29.

Wolverton, B. C., R. C. McDonald and W. R. Duffer. 1983. Microorganisms and higher plants for wastewater treatment. *J. Environmental Quality,* 12(2):236-242.

American Public Health Association. 1981. *Standard Methods for the Examination of Water and Wastewater.* 15th Ed. American Public Health Assn., Washingon, DC.